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1. Your reference	X341b	
2. Patent application number *(The Patent Office will fill in this part)*	**9919201.5**	14 AUG 1999
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Xaar Technology Limited Science Park Milton Road Cambridge CB4 0XR	
Patents ADP number *(if you know it)*	7301877002 IJ	
If the applicant is a corporate body, give the country/state of its incorporation	UK	
4. Title of the invention	Droplet Deposition Apparatus	
5. Name of your agent *(if you have one)*		
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	~~Ian Hartwell Xaar Technology Limited Science Park Milton Road Cambridge CB4 0XR~~	MATHYS + SQUIRE 100 GRAYS INN ROAD LONDON WC1X 8AL
Patents ADP number *(if you know it)*	6631840003 IJ	F51/77 28-9-99

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Signature I. Hartwell Date 13/8/99

12. Name and daytime telephone number of person to contact in the United Kingdom

Ian Hartwell (01223) 423663

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Droplet Deposition Apparatus

The present invention relates to droplet deposition apparatus, particularly inkjet printheads, components thereof and methods for manufacturing such components.

Figure 1 shows a prior art inkjet printhead 1 of the kind disclosed in WO91/17051 and comprising a sheet 3 of piezoelectric material, for example lead zirconium titanate (PZT), formed in a top surface thereof with an array of open-topped ink channels 7. As evident from figure 2, which is a sectional view taken along line AA of figure 1, successive channels in the array are separated by side walls 13 which comprise piezoelectric material poled in the thickness direction of the sheet 3 (as indicated by arrow P). On opposite channel-facing surfaces 17 are arranged electrodes 15 to which voltages can be applied via connections 34. As is known, e.g. from EP-A-0 364 136, application of an electric field between the electrodes on either side of a wall results in shear mode deflection of the wall into one of the flanking channels – this is shown exaggerated by dashed lines in figure 2 – which in turn generating a pressure pulse in that channel.

The channels are closed by a cover 25 in which are formed nozzles 27 each communicating with respective channels at the mid-points thereof. Droplet ejection from the nozzles takes place in response to the aforementioned pressure pulse, as is well known in the art. Supply of droplet fluid into the channels, indicated by arrows S in figure 2, is via two ducts 33 cut into the bottom face 35 of sheet 3 to a depth such that they communicate with opposite ends respectively of the channels 7. Such a channel construction may consequently be described a double-ended side-shooter arrangement. A cover plate 37 is bonded to the bottom face 35 to close the ducts.

Figures 3 and 4 are exploded perspective and sectional views respectively of a printhead employing the double-ended side-shooter concept of figures 1 and 2 in a "pagewide" configuration. Such a printhead is described in co-pending PCT application no. PCT/GB98/01495, incorporated herein by reference. Two rows of channels spaced relatively to one another in the media feed direction are used, with each row extending the width of a page in a direction "W" transverse to a media feed direction P. Features common with the embodiment of figures 1 and 2 are indicated by the same reference figures used in figures 1 and 2.

As shown in figure 4, which is a sectional view taken perpendicular to the direction W, two piezoelectric sheets 3a, 3b each having channels (formed in their bottom surface rather than their top as in the previous example) and electrodes as described above are closed (again on their bottom surface rather than their top) by a flat, extended cover 25 in which openings 96a,96b for droplet ejection are formed. Cover 25 is also formed with conductive tracks (not shown) which are electrically connected to respective channel electrodes, e.g. by solder bonds as described in WO92/22429 (X238), and which extend to the edge of the cover where respective drive circuitry (integrated circuits 84a,84b) for each row of channels is located.

Such a construction has several advantages, particularly with regard to manufacture. Firstly, extended cover 25 acts as a "backbone" for the printhead, supporting the piezoelectric sheets 3a,b and integrated circuits 84a,84b during manufacture. This support function is particularly important during the process of butting together multiple sheets 3 to form a single, contiguous, pagewide array of channels, as indicated at 82a and b in the perspective view of figure 3. One approach to butting is described in WO91/17051 and consequently not in any further detail here. The size of the extended cover also simplifies handling.

Another advantage arises from the fact that the surface of the cover on which the conductive tracks are required to be formed is flat, i.e. it is free of any substantial discontinuities. As such, it allows many of the manufacturing steps to be carried out using proven techniques used elsewhere in the electronics industry, e.g. photolithographic patterning for the conductive tracks and "flip chip" for the integrated circuits. Photolithographic patterning in particular is unsuitable where a surface undergoes rapid changes in angle due to problems associated with the spinning method typically used to apply photolithographic films. Flat substrates also have advantages from the point of view of ease of processing, measuring, accuracy and availability.

A prime consideration when choosing the material for the cover is, therefore, whether it can easily be manufactured into a form where it has a surface free of substantial discontinuities. A second requirement is for the material to have thermal expansion characteristics to the piezoelectric material used elsewhere in the printhead. A final requirement is that the material be sufficiently robust to withstand the various

manufacturing processes. Aluminium nitride, alumina, INVAR or special glass AF45 are all suitable candidate materials.

The droplet ejection openings 96a,b may themselves be formed with a taper, as per the embodiment of figure 1, or the tapered shape may be formed in a nozzle plate 98 mounted over the opening. Such a nozzle plate may comprise any of the readily-ablatable materials such as polyimide, polycarbonate and polyester that are conventionally used for this purpose. Furthermore, nozzle manufacture can take place independently of the state of completeness of the rest of the printhead: the nozzle may be formed by ablation from the rear prior to assembly of the active body 82a onto the substrate 86 or from the front once the active body is in place. Both techniques are known in the art. The former method has the advantage that the nozzle plate can be replaced or the entire assembly rejected at an early stage in assembly, minimising the value of rejected components. The latter method facilitates the registration of the nozzles with the channels of the body when assembled on the substrate.

Following the mounting of piezoelectric sheets 3a,b and drive chips 84a,84b onto the substrate 86 and suitable testing - as described, for example, in EP-A-0 376 606 – a base 80 can be attached. This too has several functions, the most important of which is to define, in cooperation with s manifold chambers 90,88 and 92 between and to either side of the two channel rows 82a,b respectively. Base 80 is further formed with respective conduits as indicated at 90',88' and 92' through which ink is supplied from the outside of the printhead to each chamber. It will be evident that this results in a particularly compact construction in which ink can be circulated from common manifold 90, through the channels in each of the bodies (for example to remove trapped dirt or air bubbles) and out through chambers 88 and 92. Base 80 also provides surfaces for attachment of means for locating the completed printhead in a printer and defines further chambers 94a,94b, sealed from ink-containing chambers 88,90,92 and in which integrated circuits 84a,b can be located.

The present invention seeks to simplify yet further the manufacture of printheads utilising the "flat cover member" concept described above.

Accordingly, the present invention consists in one aspect in a method of manufacturing a component of a droplet deposition apparatus, the method comprising the steps of:

providing a body of piezoelectric material and a separate base having a surface free of substantial discontinuities;

forming a plurality of channels in the body;

attaching the body to said surface of the base;

depositing a layer of conductive material so as to extend continuously over said at least one channel surface and said surface of the base;

defining an electrode on said at least one channel surface and a conductive track connected thereto on said surface of the base.

The attachment of the body to a surface of the base and subsequent deposition of a continuous layer of conductive material over said at least one channel surface and said base surface results in an effective electrical connection between channel wall electrodes and substrate conductive tracks.

The present invention also consists in a component for a droplet deposition apparatus comprising:

a body of piezoelectric material formed with a plurality of channels;

a separate base having a surface free of substantial discontinuities;

wherein the body is attached to said surface and a layer of conductive material extends continuously over said at least one surface of a channel and said surface, thereby defining an electrode on said at least one channel surface and a conductive track connected thereto on said surface of the base.

Further aspects of the invention are set out in the description that follow, which concerns an example only and which makes reference to the following figures:

Figure 5 is an assembled sectional view, similar to that of figure 4, of a printhead according to a first embodiment of the invention;

Figures 6(a) and 6(b) are detail sectional views taken perpendicular and parallel to the channel axis of the device of figure 5;

Figure 7 is a detail perspective view of the device of figure 5;

Figure 8 is a cross-sectional view through a channel of a printhead according to a second embodiment of the invention;

Figures 9-11 are a sectional views along the channel of third, fourth and fifth embodiments of the invention respectively;

Figures 12 and 13 are perspective and detail perspective views respectively of the embodiment of figure 11.

Figure 14 is a detail view of the area denoted by reference figure 194 in figure 6(b).

Figure 15 is a perspective view showing a step in the manufacture of a printhead of the kind shown in figure 11;

Figure 16 is a detail view taken along arrow 660 of figure 15

Figures 17 and 18 corresponding to the view of figure 16 following channel formation.

Reference is first made to figure 5, which is a sectional view similar to that of figure 4 and illustrating a printhead of the kind discussed with regard to figures 1-4 and in accordance with the present invention. Wherever features are common with the embodiments of figure 1-4, the same reference figures as used in figures 1-4 have been used.

As with the previous embodiments, the printhead of figure 5 comprises a "pagewide" substrate 86 on which two rows of integrated circuits 84 are mounted. In-between lies a row of channels 82 formed in the substrate 84, each channel of which communicates with two spaced nozzles 96a, 96b for droplet ejection and with manifolds 88,92 and 90 arranged to either side and between nozzles 96a,96b respectively for ink supply and circulation.

In contrast to the printhead embodiments discussed above, the piezoelectric material for the channel walls is incorporated in a layer 100 made up of two strips 110a, 110b. As in the embodiment of figure 4, these strips will be butted together in the pagewidth direction W, each strip extending approximately 5-10 cm (this being the typical dimension of the wafer in which form such material is generally supplied). Prior to channel formation, each strip is bonded to the continuous planar surface 120 of the substrate 86, following which channels are sawn or otherwise formed so as to extend through both strip and substrate. A cross-section through a channel, its associated actuator walls and nozzle is shown in figure 6. Such an actuator wall construction is

known, e.g. from EP-A-0 505 065 and consequently will not be discussed in any greater detail. Similarly, appropriate techniques for removing both the glue bonds between adjacent butted strips of piezoelectric material and the glue relief channels used in the bond between each piezoelectric strip and the substrate are known from US 5,193,256 and WO95/04658 respectively.

In accordance with the present invention, a continuous layer of conductive material is then applied over the channel walls and substrate. Not only does this form electrodes 190 for application of electric fields to the piezoelectric walls 13 - as illustrated in figure 6(a) - and conductive tracks 192 on substrate 86 for supply of voltages to those electrodes - as shown in figure 6(b) - it also forms an electrical connection between these two elements as shown at 194.

Appropriate electrode materials and deposition methods are well-known in the art. Copper, Nickel and Gold, used alone or in combination and deposited advantageously by electroless processes utilising palladium catalyst will provide the necessary integrity, adhesion to the piezoelectric material, resistance to corrosion and basis for subsequent passivation e.g. using Silicon Nitride as known in the art.

As is generally known, e.g. from the aforementioned EP-A-0 364 136, the electrodes on opposite sides of each actuator wall 13 must be electrically isolated from one another in order that an electric field may be established between them and hence across the piezoelectric material of the actuator wall. This is shown in both the prior art arrangement of figure 2 and the embodiment of the present invention shown in figure 6(a). The corresponding conductive tracks connecting each electrode with a respective voltage source must be similarly isolated.

In the present invention, such isolation may be achieved at the time of deposition, for example by masking those areas - such as the tops of the channel walls - where conductive material is not required. Suitable masking techniques, including patterned screens and photolithographically patterned masking materials are well-known in the art, e.g. from WO98/17477 and EP-A-0 397 441, and will not be described in any further detail.

Alternatively, isolation may be achieved after deposition by removing conductive material from those areas where it is not required. Localised vaporisation of material by laser beam, as known e.g. from JP-A-09 010 983, has proved most suitable for achieving the high accuracy required, although other conventional removal methods - inter alia sand blasting, etching, electropolishing and wire erosion - may also be suitable. Figure 7 illustrates material removal, in this case over a narrow band running along the top of the wall, although several passes of the laser beam (or a single pass of a wider laser beam) can be used to remove material from the entire top surface of the wall so as to maximise the wall top area available for bonding with the cover member 130.

In addition to removing conductive material from the top surface 13' of each piezoelectric actuator wall 13 so as to separate the electrodes 190', 190" on either side of each wall, conductive material must also be removed from the surface of the substrate 86 in such a way as to define respective conductive tracks 192', 192" for each electrode 190', 190". At the transition between piezoelectric material 100 and substrate 86, the end surface of the piezoelectric material 100 is angled or chamfered as shown at 195. As is known, this has the advantage over a perpendicular cut (of the kind indicated by a dashed line at 197) of allowing the vapourising laser beam – shown figuratively by arrow 196 – to impinge on and thereby remove the conductive material without requiring angling of the beam. Preferably, the chamfer 195 is formed by milling after the piezoelectric layer 100 has been attached to the substrate 86 but before the formation of the channel walls which, being typically 300μm thick and formed of ceramic and glass, are vulnerable to damage. A chamfer angle of 45 degrees has been found to be suitable.

It will also be appreciated that the electrodes and conductive tracks associated with the active portions 140a need to be isolated from those associated with 140b in order that the rows of nozzles might be operated independently. Although this too may be achieved by a laser "cut" along the surface of the substrate 86 extending between the two piezoelectric strips, it is more simply achieved by the use of a physical mask during the electrode deposition process or by the use of electric discharge machining.

Laser machining can also be used in a subsequent step to form the ink ejection holes 96a,96b in the base of each channel, as is known in the art. Such holes may directly serve as ink ejection nozzles. Alternatively, there may be bonded to the lower

surface of the substrate 86 a separate plate (not shown) having nozzles that communicate with the holes 96a,b and which are of a higher quality that might otherwise be possible with nozzles formed directly in the ceramic or glass base of the channel. Appropriate techniques are well-known, particularly fromWO93/15911 which discloses a technique for the formation of nozzles in situ, after attachment of the nozzle plate, thereby simplifying registration of each nozzle with its respective channel.

The conductive tracks 192', 192" defined by laser may extend all the way from the transition area 195 to the integrated circuits 84 located at either side of the substrate. Alternatively, the laser track definition process may be restricted to an area directly adjacent the piezoelectric material and a different –e.g. photolithographic – process used to define further conductive tracks that connect the laser-defined tracks with the integrated circuits 86.

Having established the electrical connections, it remains only to adhesively bond (e.g. using an offset method) a cover member 130 to the surface of substrate 86. This cover fulfils several functions: firstly, it closes each channel along those portions 140a,140b where the walls incorporate piezoelectric material in order that actuation of the material and the resulting deflection of the walls might generate a pressure pulse in the channel portions and cause ejection of a droplet through a respective opening. Secondly, the cover and substrate define between them ducts 150a,b and c which extend along either side of each row of active channel portions 140a, 140b and through which ink is supplied. The cover is also formed with ports 88, 90, 92 which connect ducts 150a,b and c with respective parts of an ink system. In addition to replenishing the ink that has been ejected, such a system may also circulate ink through the channels (as indicated by arrows 112) for heat, dirt and bubble removing purposes as is known in the art. A final function of the cover is to seal the ink-containing part of the printhead from the outside world and particularly the electronics 84. This has been found to be satisfactorily achieved by the adhesive bond between the substrate 86 and cover rib 132, although additional measures such as glue fillets could be employed. Alternatively, cover rib may be replaced by an appropriately shaped gasket member.

Broadly expressed, the printhead of figure 5 includes a first layer having a continuous planar surface; a second layer of piezoelectric material bonded to said

continuous planar surface; at least one channel that extends through the bonded first and second layers; the second layer having first and second portions spaced along the length of the channel; and a third layer that serves to close on all sides lying parallel to the axis of the channel portions of the channel defined by said first and second portions of said second layer.

It will be appreciated that restricting the use of piezoelectric material to those "active" portions of the channel where it is required to displace the channel walls is an efficient way of utilising what is a relatively expensive material. The capacitance associated with the piezoelectric material is also minimised, reducing the load on – and thus the cost of - the driving circuitry.

Whereas the printhead of figures 5 and 6 employs actuator walls of the "cantilever" type in which only part of the wall distorts in response to the application of an actuating electric field, the actuator walls of the printhead of figures 8 and 9 actively distort over their entire height into a chevron shape. As is well-known and illustrated in figure 8, such a "chevron" actuator has upper and lower wall parts 250,260 poled in opposite directions (as indicated by arrows) and electrodes 190',190" on opposite surfaces for applying a unidirectional electric field over the entire height of the wall. The approximate distorted shape of the wall when subjected to electric fields is shown exaggerated in dashed lines 270 on the right-hand side of figure 8.

Various methods of manufacturing such "chevron" actuator walls are known in the art, e.g. from EP-A-0 277 703, EP-A-0 326 973 and WO92/09436. For the printhead of figures 9 and 10, two sheets of piezoelectric material are first arranged such that their directions of polarisation face one another. The sheets are then laminated together, cut into strips and finally bonded to an inactive substrate 86, as already explained with regard to figure 5.

One consequence of the entire actuator wall height being defined by piezoelectric material is that there is no need to saw wall-defining grooves into the inactive substrate 86. There remains, of course, the need for the length of the nozzles 96a,96b to be kept to a minimum so as to minimise losses that would otherwise reduce the droplet ejection velocity. To this end, the substrate can be reduced in thickness either locally – by means of a trench 300 as shown in figure 9 and formed

advantageously by sawing, grinding or moulding – or overall per figure 10. Both arrangements need to provide free passage for a disc cutter (shown diagrammatically in dashed lines at 320) used to form the channels in the piezoelectric strips.

Following channel formation and in accordance with the present invention, conductive material is then deposited and electrodes / conductive tracks defined. In the examples shown, piezoelectric strips 110a and 110b are chamfered to facilitate laser patterning, as described above. Nozzle holes 96a,b are also formed at two points along each channel.

Finally a cover member 130 is bonded to the tops of the channel walls so as to create the closed, "active" channel lengths necessary for droplet ejection. In the printhead of figure 9, the cover member need only comprise a simple planar member formed with ink supply ports 88,90,92 since gaps 150 a,b,c necessary for distributing the ink along the row of channels are defined between the lower surface 340 of that cover member 130 and the surface 345 of the trench 300. Sealing of the channels is achieved at 330 by the adhesive bond (not shown) between the lower surface 340 of the cover 130 and the upper surface of the substrate. Broadly expressed, the printhead of this third invention embodiment includes a first layer of inactive material; a second layer of piezoelectric material comprising first and second portions formed with channels and bonded to the first layer in a spaced relationship; a third layer that serves to close the channels on all sides lying parallel to their axes; and outlets formed in the first layer for ink ejection from said channels in said portions of the second layer.

In the embodiment of figure 10, the simplicity of substrate 86 formed without trench 300 is offset by the need to form a trench-like structure 350 (defined, for example, by a projecting rib 360) in the cover 130 so as to define ink supply ducts 150a,b,c.

Turning to the embodiment of figure 11, this also employs the combination of a simple substrate 86 and a more-complex cover 130, in this case a composite structure made up of a spacer member 410 and a planar cover member 420. Unlike previous embodiments, however, it is the substrate 86 rather than the cover that is formed with ink supply ports 88,90,92 and the cover 130 rather than the substrate that is formed with

holes 96 for droplet ejection. In the example shown, these holes communicate with nozzles formed in a nozzle plate 430 attached to the planar cover member 420.

Figure 12 is a cut-away perspective view of the printhead of figure 11 seen from the cover side. The strips 110a, 110b of "chevron"-poled piezoelectric laminate have been bonded to substrate 86 and subsequently cut to form channels. A continuous layer of conductive material has then been deposited over the strips and parts of the substrate and electrodes and conductive tracks defined thereon in accordance with the present invention. As explained with regard to figures 5 and 6, the strips are chamfered on either side (at 195) to aid laser patterning in this transition area.

Figure 13 is an enlarged view with spacer member 410 removed to show the conductive tracks 192 in more detail. Although not shown for reasons of clarity, it will be appreciated that these, like channels 7, extend across the entire width of the printhead. In the area of the substrate adjacent each strip (indicated by arrow 500 with regard to strip 110b) the tracks are continuous with the electrodes (not shown) on the facing walls of each channel, having been deposited in the same manufacturing step. This provides an effective electrical contact in accordance with the present invention.

However, elsewhere on the substrate - as indicated at 510 - more conventional techniques, for example photolithographic, can be used to define not only tracks 192 leading from the channel electrodes to the integrated circuits 84 but also further tracks 520 for conveying power, data and other signals to the integrated circuits. Such techniques may be more cost effective, particularly where the conductive tracks are diverted around ink supply ports 92 and which would otherwise require complex positional control of a laser. They are preferably formed on the alumina substrate in advance of the ink supply ports 88,90,92 being drilled (e.g. by laser) and of the piezoelectric strips 110a,b being attached, chamfered and sawn. Following deposition of conductive material in the immediate area of the strips, a laser can then be used to ensure that each track is connected only with its respective channel electrode and no other.

Thereafter, both electrodes and tracks will require passivation, e.g. using Silicon Nitride deposited in accordance with WO95/07820. Not only does this provides

protection against corrosion due to the combined effects of electric fields and the ink (it will be appreciated that all conductive material contained within the area 420 defined by the inner profile 430 of spacer member 410 will be exposed to ink), it also prevents the electrodes on the opposite sides of each wall being short circuited by the planar cover member 430. Both cover and spacer are advantageously made of molybdenum which, in addition to having similar thermal expansion characteristics to the alumina used elsewhere in the printhead, can be easily machined, e.g. by etching, laser cutting or punching, to high accuracy. This is particularly important for the holes for droplet ejection 96 and, to a lesser extent, for the wavy, bubble-trap-avoiding, inner profile 430 of the spacer member 410. Bubble traps are further avoided by positioning the trough 440 of the wavy profile such that it aligns with or even overlies the edge of the respective ink port 92. Crest 450 of the wavy profile is similarly dimensioned (to lie a distance - typically 3mm, approximately 1.5 times the width of each strip 110a,b – from the edge of the adjacent strip 110a,b) to ensure avoidance of bubble traps without affecting the ink flow into the channels.

Spacer member 410 is subsequently secured to the upper surface of substrate 86 by a layer of adhesive. In addition to its primary, securing function, this layer also provides back-up electrical isolation between the conductive tracks on the substrate. Registration features such as notch 440 are used to ensure correct alignment.

The last two members to be adhesively attached – either separately or following assembly to one another - are the planar cover member 420 and nozzle plate 430. Optical means may be employed to ensure correct registration between the nozzles formed in the nozzle plate and the channels themselves. Alternatively, the nozzles can be formed once the nozzle plate is in situ as known, for example, from WO93/15911.

It has been found advantageous to use at various points in the printhead an adhesive that is "filled", i.e. that contains particles having a stiffness greater than that of the adhesive itself. At the bond between the strips of piezoelectric material 110a,b and the surface of the substrate 86 this ensures a more rigid joint and a more rigid actuator wall overall. This in turn increases actuator efficiency – a principle known, for example, from EP-A-0 277 703. Ceramic particles - e.g. of Aluminium Oxide, Silicon Carbide,

fumed Silica or Silica flour – used at 30-50% w/w with epoxy adhesives such as Epotek (Trademark) or Ablebond (Trademark) have proved particularly effective.

A further advantage of "filling" is illustrated in figure 14, which is a detail view of the area denoted by reference figure 194 in figure 6(b). The fillet 550 created when adhesive is squeezed out during creating of the joint between the piezoelectric layer 100 and substrate 86 is advantageously retained when chamfer 195 is formed on the end surface of the layer as described above. The ceramic particles in this adhesive fillet are subsequently exposed when the assembly is subjected to a pre-plating cleaning step (e.g. plasma etching) and provide a good key for the electrode material 190 in an area that would otherwise be vulnerable to plating faults.

A final advantage is explained with reference to figures 15-18. As already explained above, the piezoelectric material for the channel walls is incorporated in a layer 100 made up of two strips 110a,110b each butted with other strips in the direction W necessary for a wide array of channels. Depending on whether the actuator is of the "cantilever" or "chevron" type, the piezoelectric layer will be polarised in one or two (opposed) directions and, in the latter case, may be formed from two oppositely-polarised sheets laminated together as shown at 600 and 610 in figure 15. To facilitate relative positioning, strips 110a,110b are connected together by a bridge piece 620 that is removed in the chamfering step that takes place once strip 100 and substrate 86 have been bonded together using adhesive.

As has already been mentioned, uniformity of the strip-substrate bond is ensured by the use of adhesive flow relief channels 630 formed in the lower surface of the strip at locations corresponding to the ink channels formed in a subsequent step. A further relief channel is formed at the butt joint 650 between strips by half channels 640 formed in respective ends of the strips. As shown in figure 16, which is a detail view taken along arrow 660 of figure 15, preferably sufficient adhesive 670 is applied to completely fill the relief channels 640.

Once the adhesive bond 670 has cured, ink channels 7 are formed in the top surface of the piezoelectric layer. Figure 17 shows how the channels are so positioned and are cut to such a depth that they communicate with the glue relief channels 630,

possibly even removing some of the adhesive in the relief channels. Similarly, the ink channel 7' formed at the butt joint 650 – a principle known from the aforementioned US 5,193,256 – communicates with the relief channel formed from half channels 640. As a result, each of the channel walls 13 is connected to its neighbour only by adhesive 670, reducing the crosstalk that would otherwise take place through the piezoelectric base material (this problem is discussed in more detail in EP-A-0 364 136.

Furthermore, this technique ensures that any part of the channel wall 13 extending below the depth of the channel proper is supported on either side by a fillet 680 of adhesive that itself has a high stiffness by dint of the ceramic filler. The stiffness of the joint at the bottom of the wall therefore remains uniform – an important factor in the uniformity of ejection velocity between channels (EP-A-0 364 136 is again referred to in this regard) which in turn is a well-known, key factor affecting the quality of the printed image.

The effect is discussed in more detail with reference to figure 18. Part (a) of the figure depicts channel walls 13a and 13b attached to a substrate 86 having an uneven surface (represented by slope 700) by means of a constant-thickness adhesive layer 710. Channels 7 are also of constant depth ,d, as a result of the top surface 720 of the piezoelectric strip having been planarised prior to channel formation e.g. by sawing with a disc cutter as is known in the art. "d" is also the "active height" of the wall, i.e. that part of the wall that deflects when subject to an electric field. It will be appreciated, however, that the joint at the bottom of the active height of wall 13a will be more flexible than that at the bottom of the active height of wall 13b as a result of the distance between the bottom of the active height and the substrate 86 - denoted 730a - being greater for wall 13a than the corresponding distance 730b for wall 13b.

Figure 18(b) shows the contrasting situation when the technique of the present application is employed. Fillet 680 of adhesive layer 670 extends to the bottom of the active height "d" of the wall regardless of the profile of the substrate 86. Bottom joint stiffness is therefore the same for both walls 13a,13b and for all walls in the printhead in general. Uniformity, at least in this respect, is therefore ensured.

The present invention has been explained with regard to the figures contained herein but is in no way restricted to such embodiments. In particular, the present techniques are applicable to printheads of varying width and resolution, pagewide double-row being merely one of many suitable configurations. Printheads having more than two rows, for example, are easily realised using tracks used in multiple layers as well-known elsewhere in the electronics industry.

All documents, particularly patent applications, referred to are incorporated in the present application by reference.

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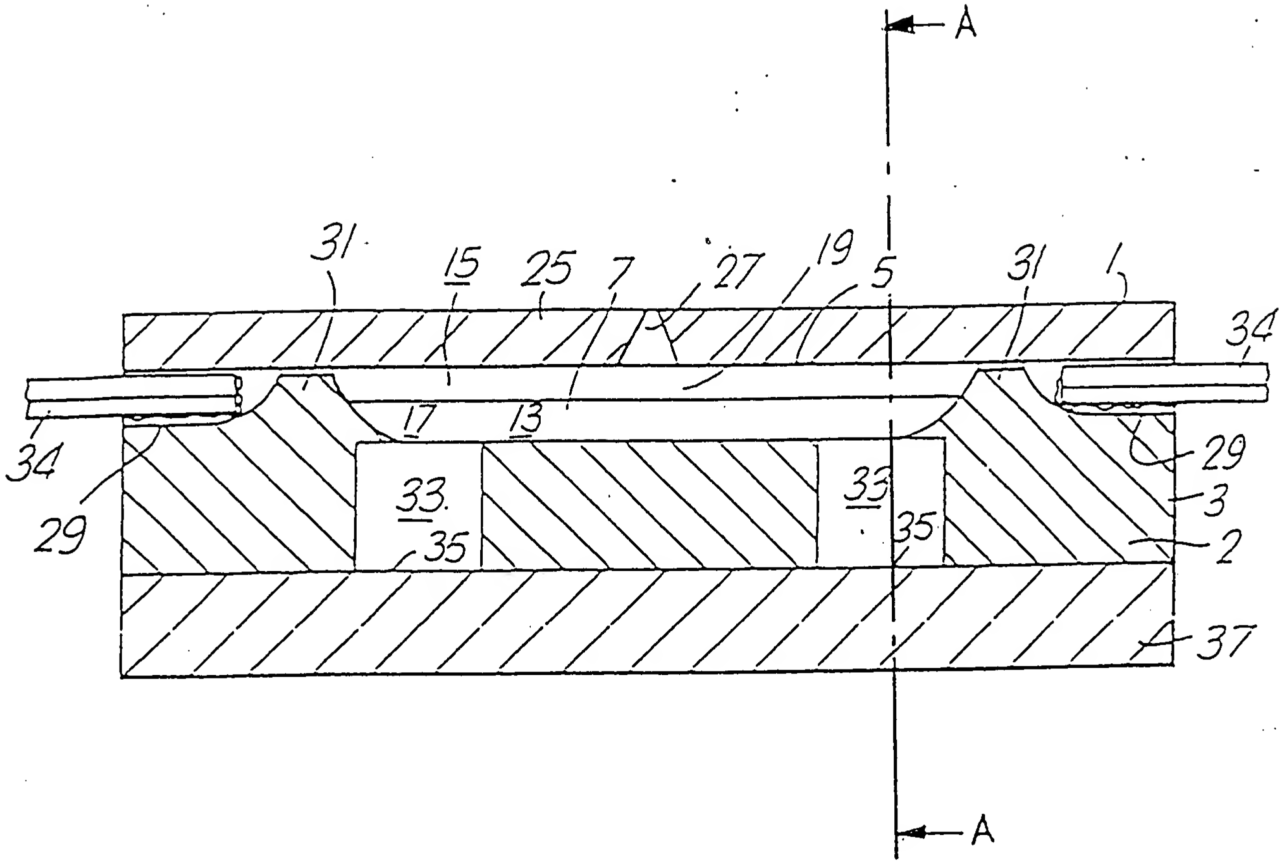


Fig. 1

Fig. 2

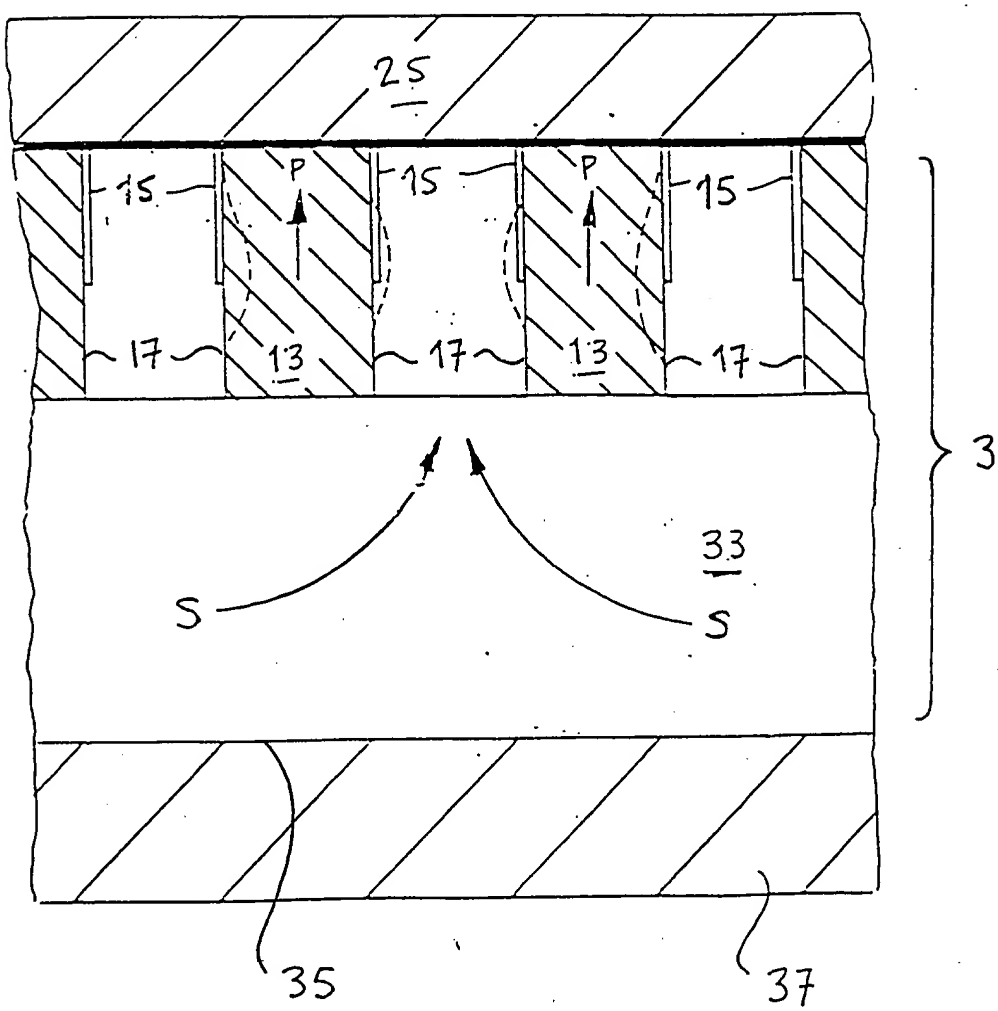


Fig. 3

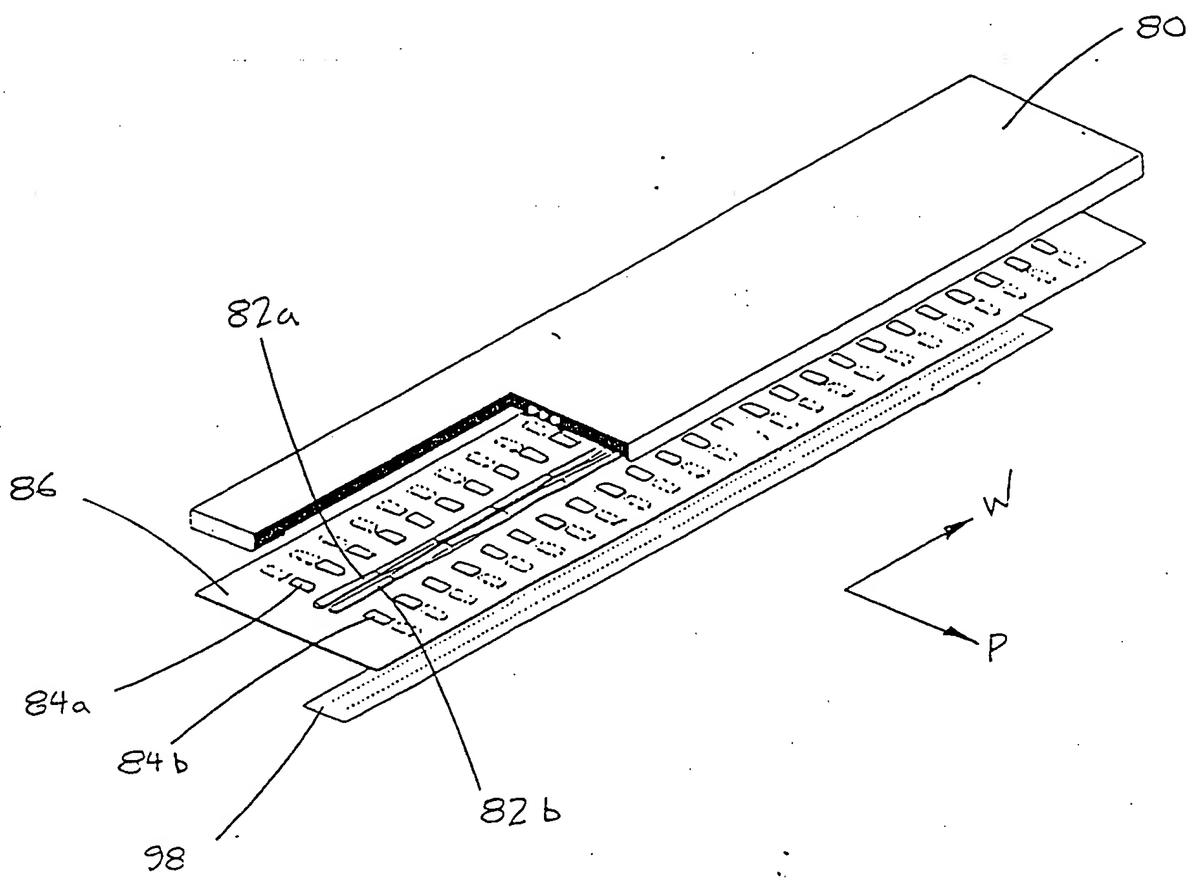


Fig. 4

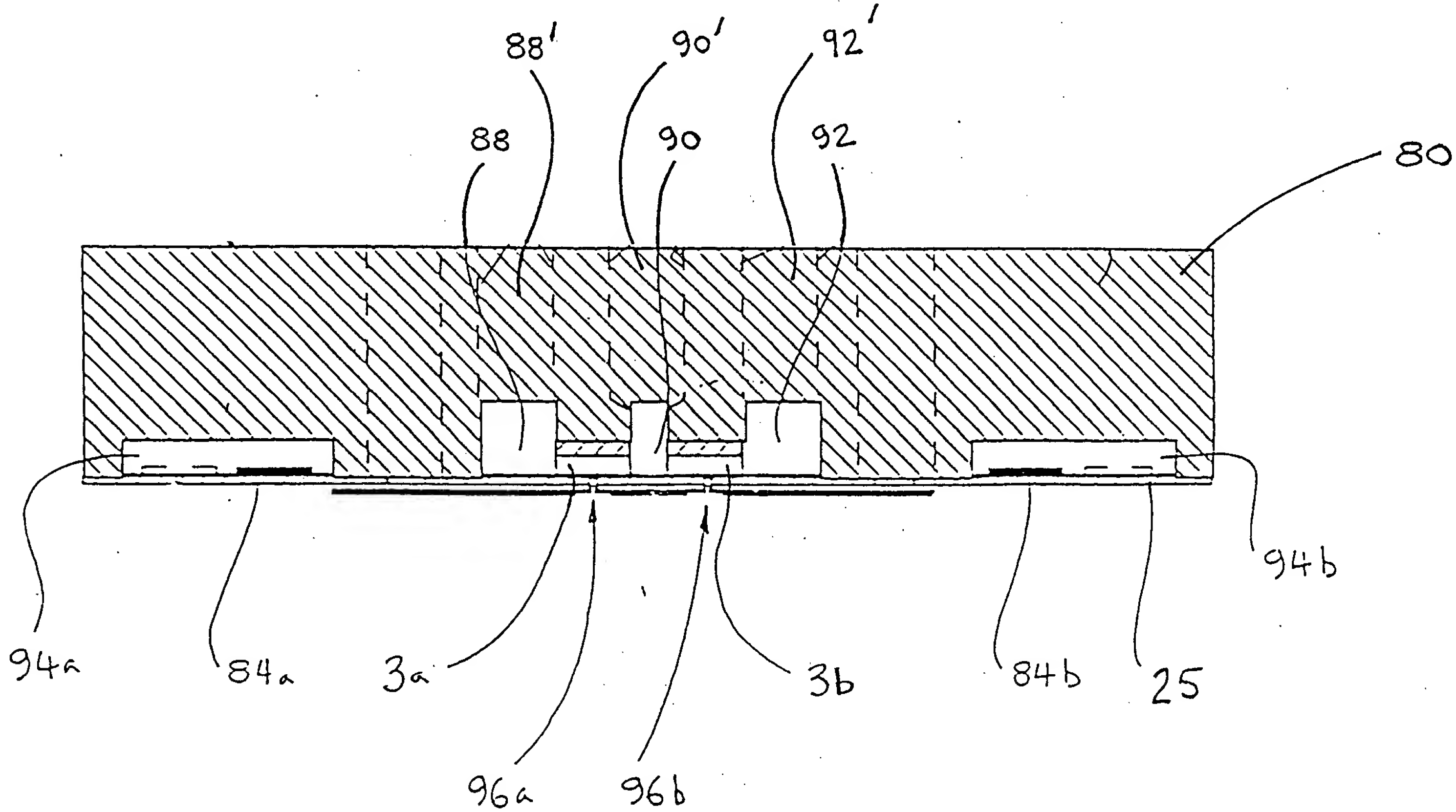
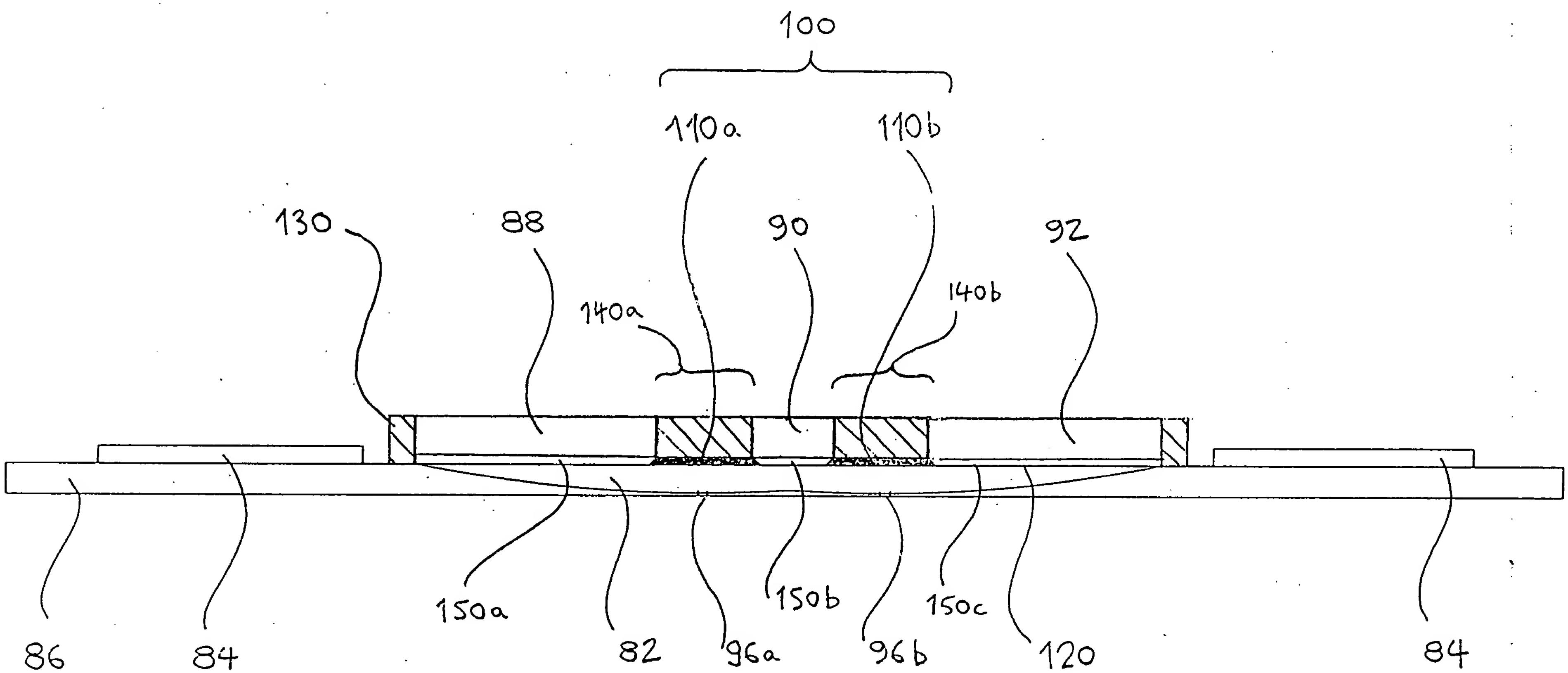


Fig. 5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84

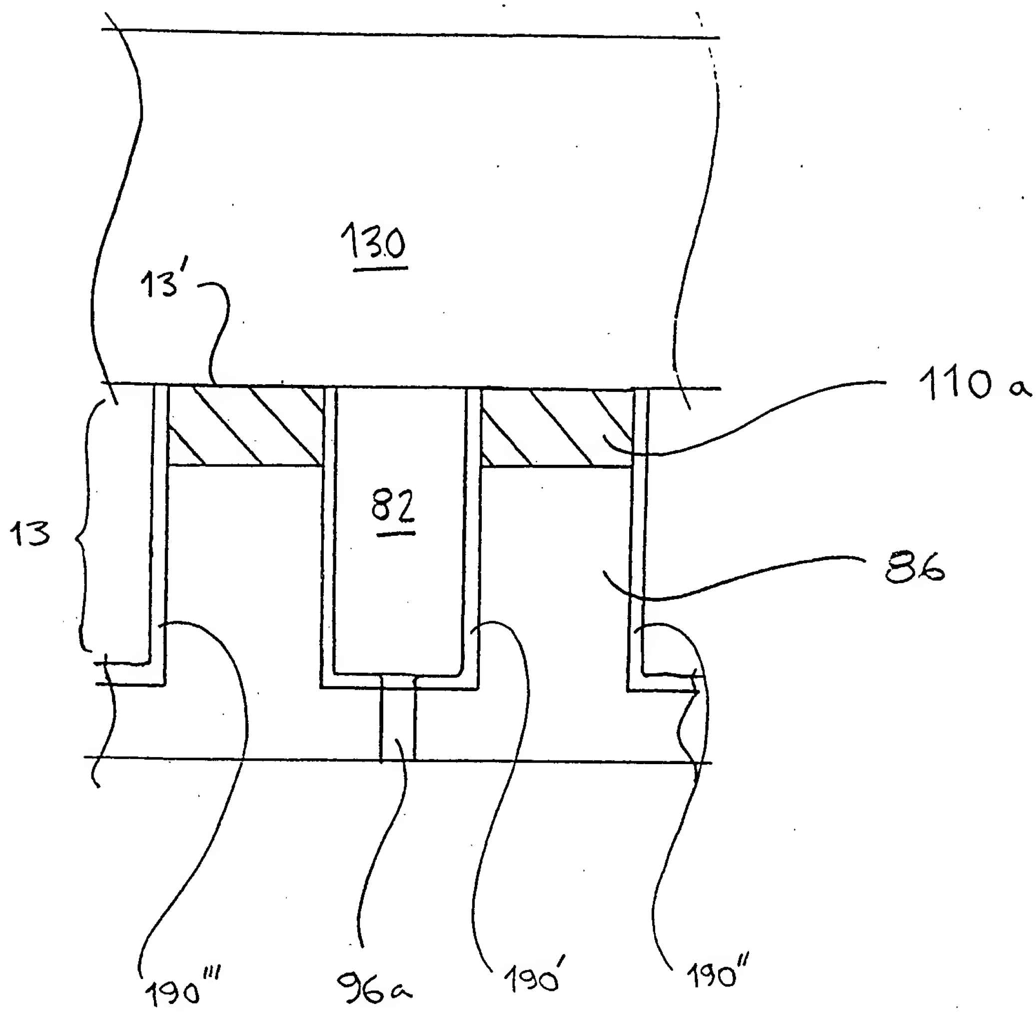


Fig. 6(a)

Fig. 6(b)

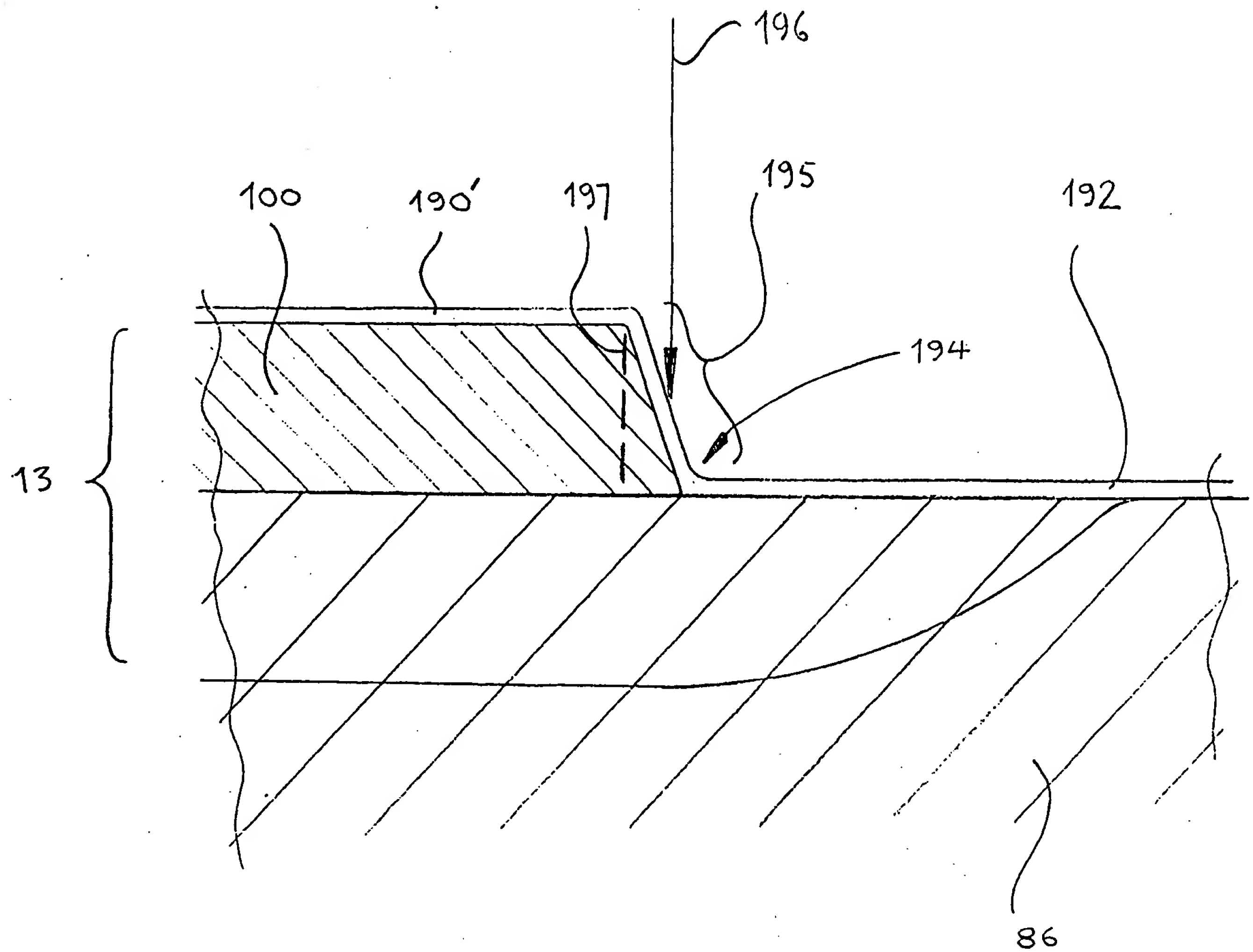
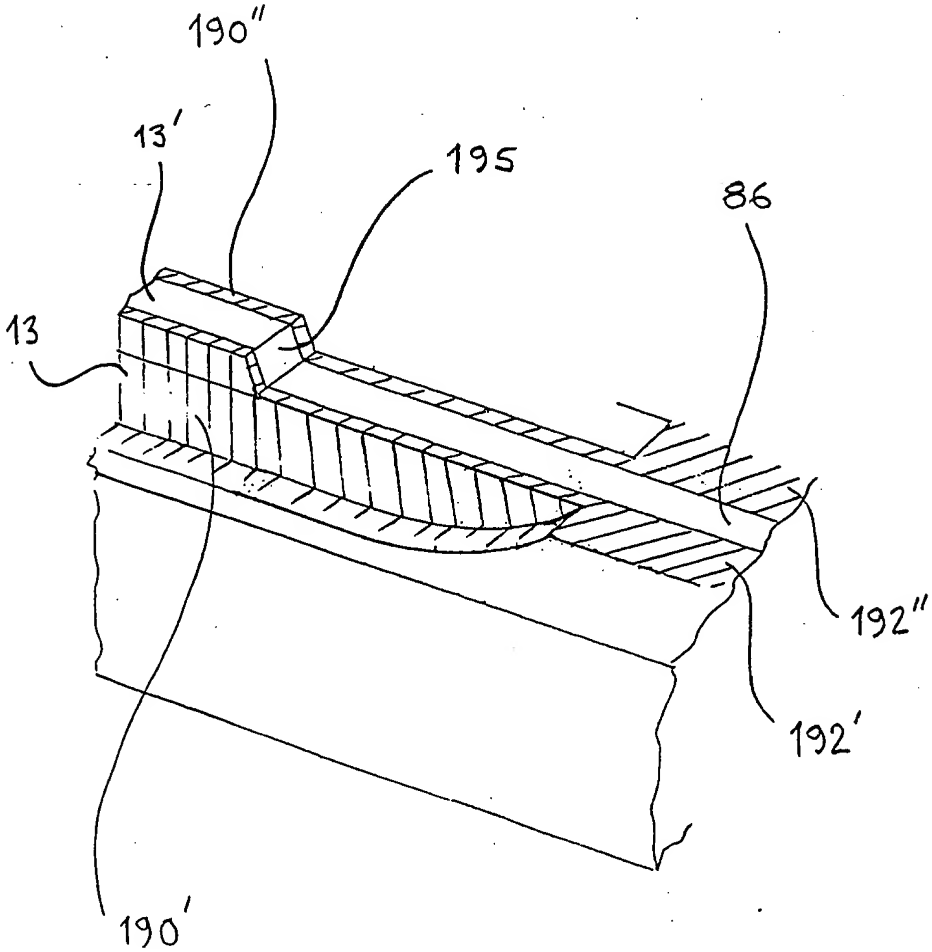


Fig. 7



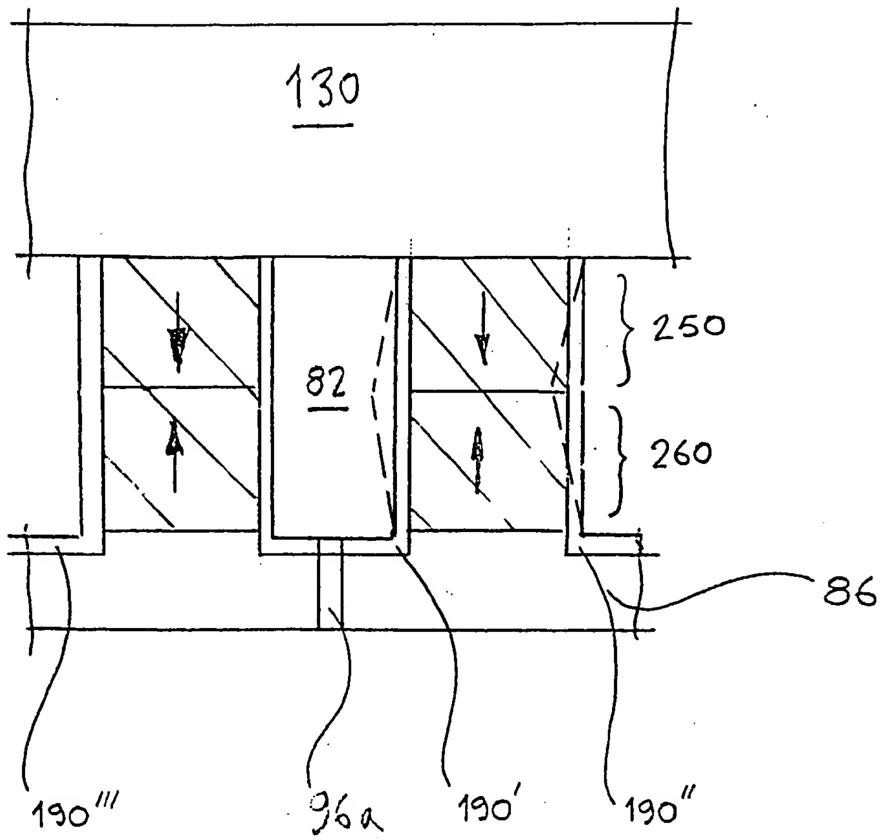
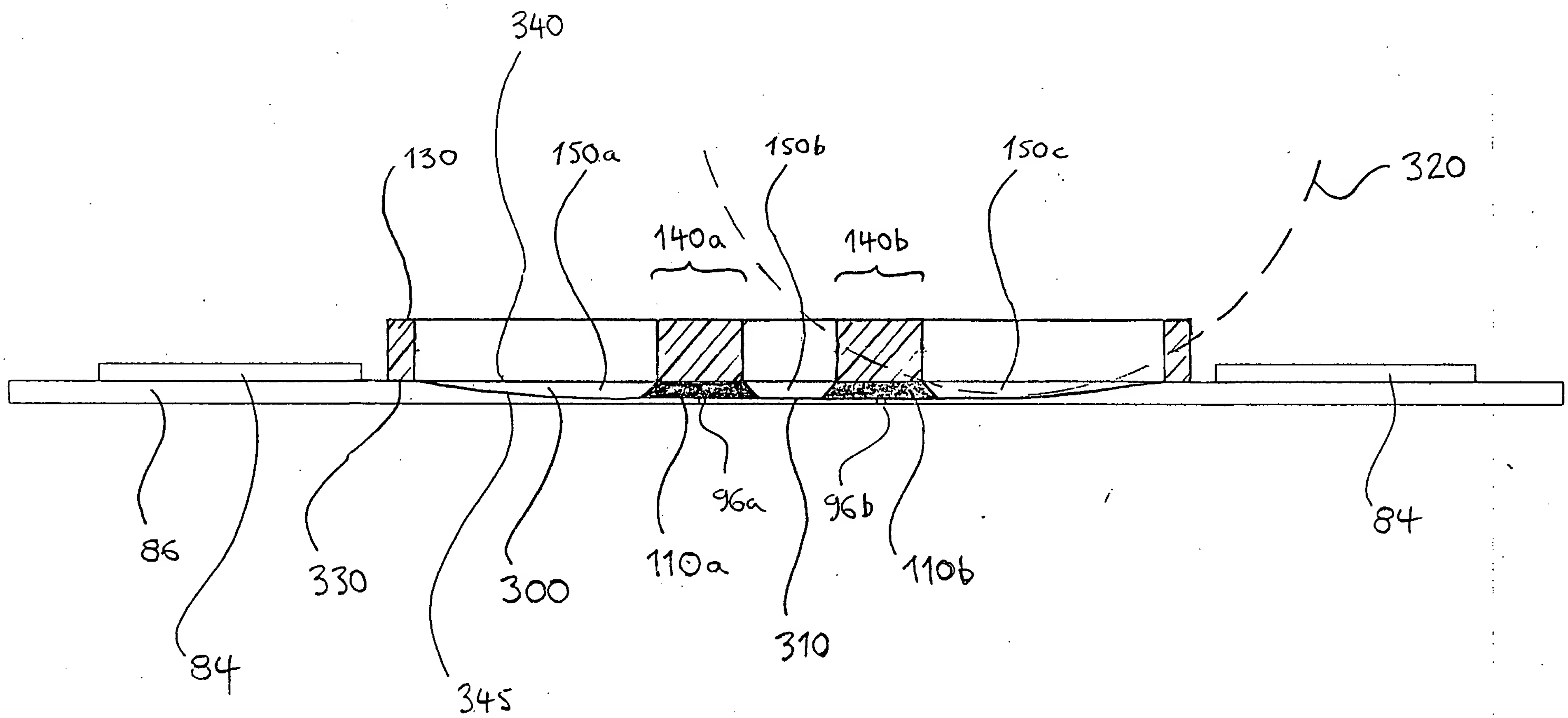


Fig. 8

Fig. 9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345
300
110a
96a
96b
310
110b
84

Fig. 10

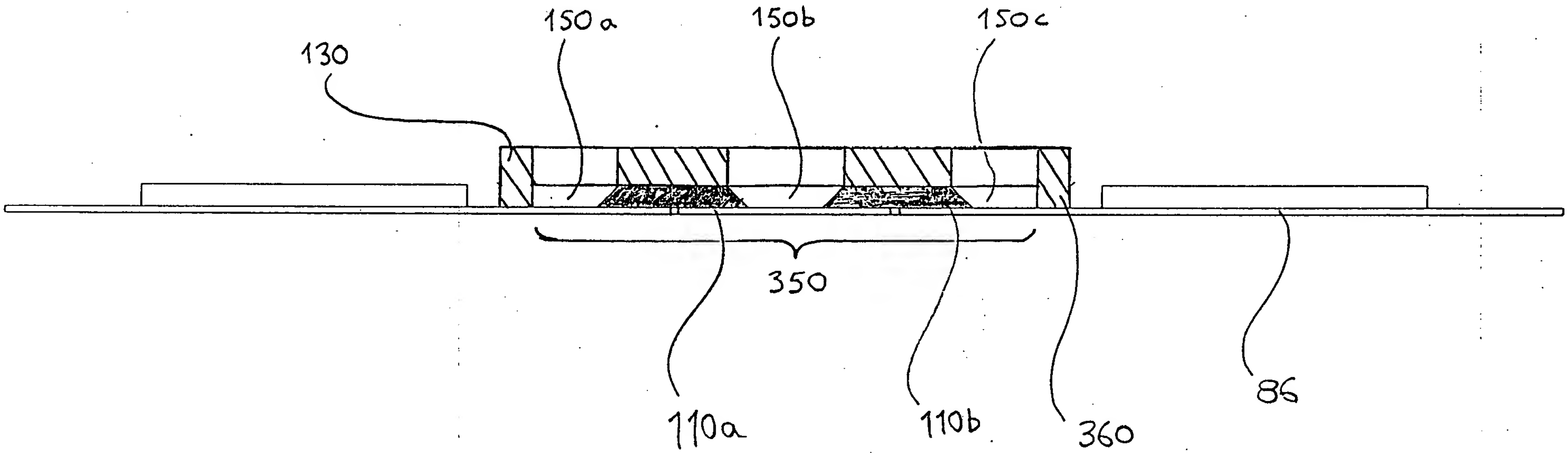


Fig. 11

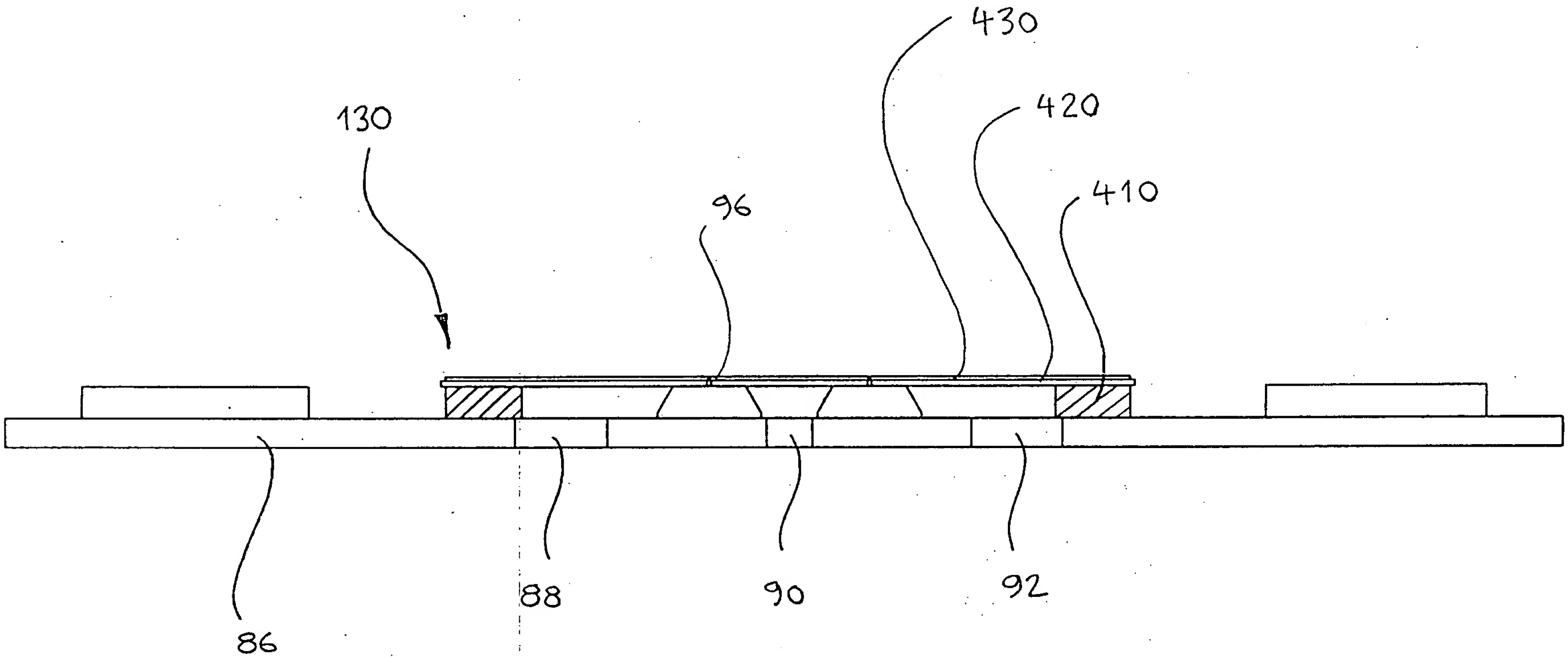


Fig. 12

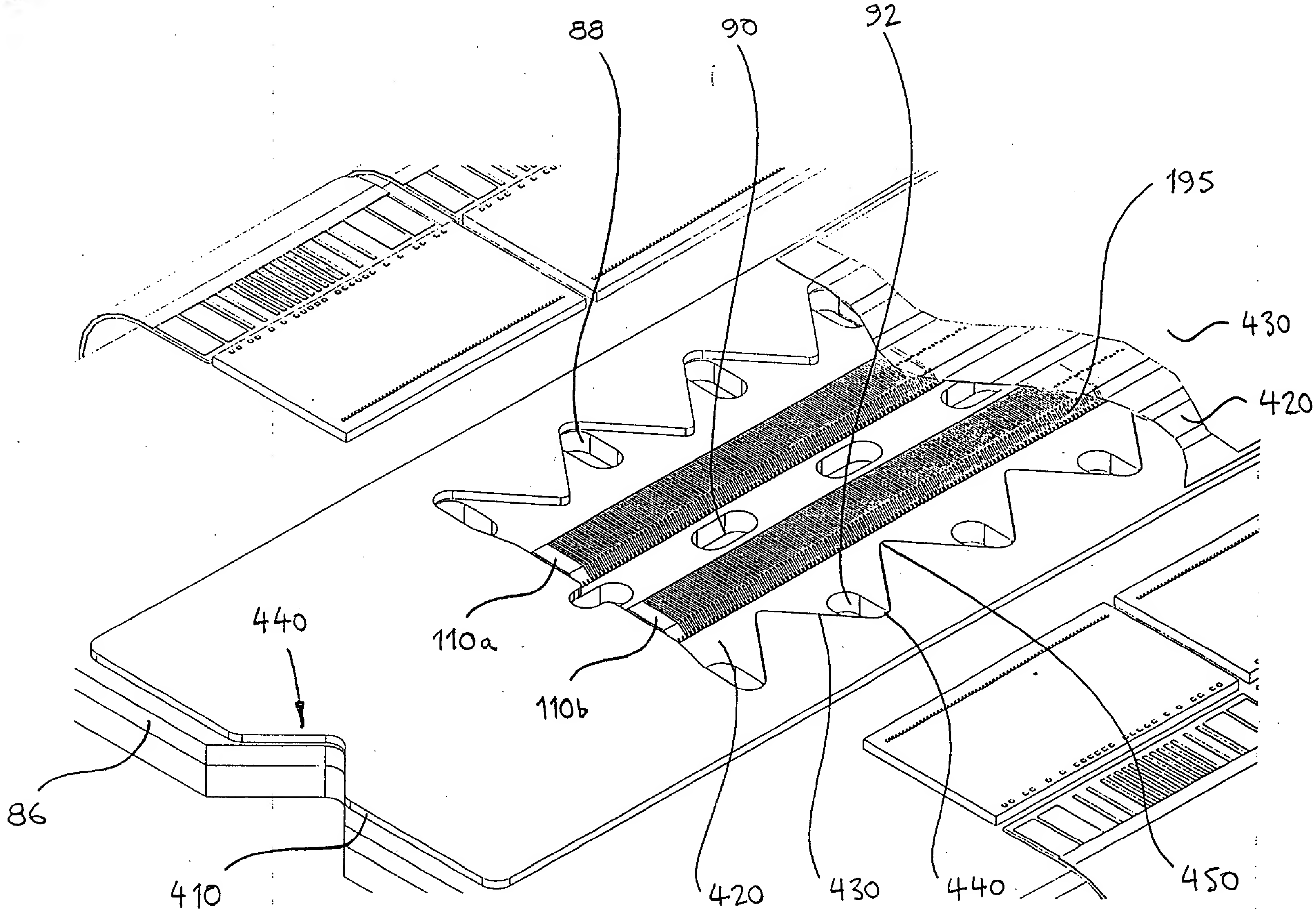


Fig. 13

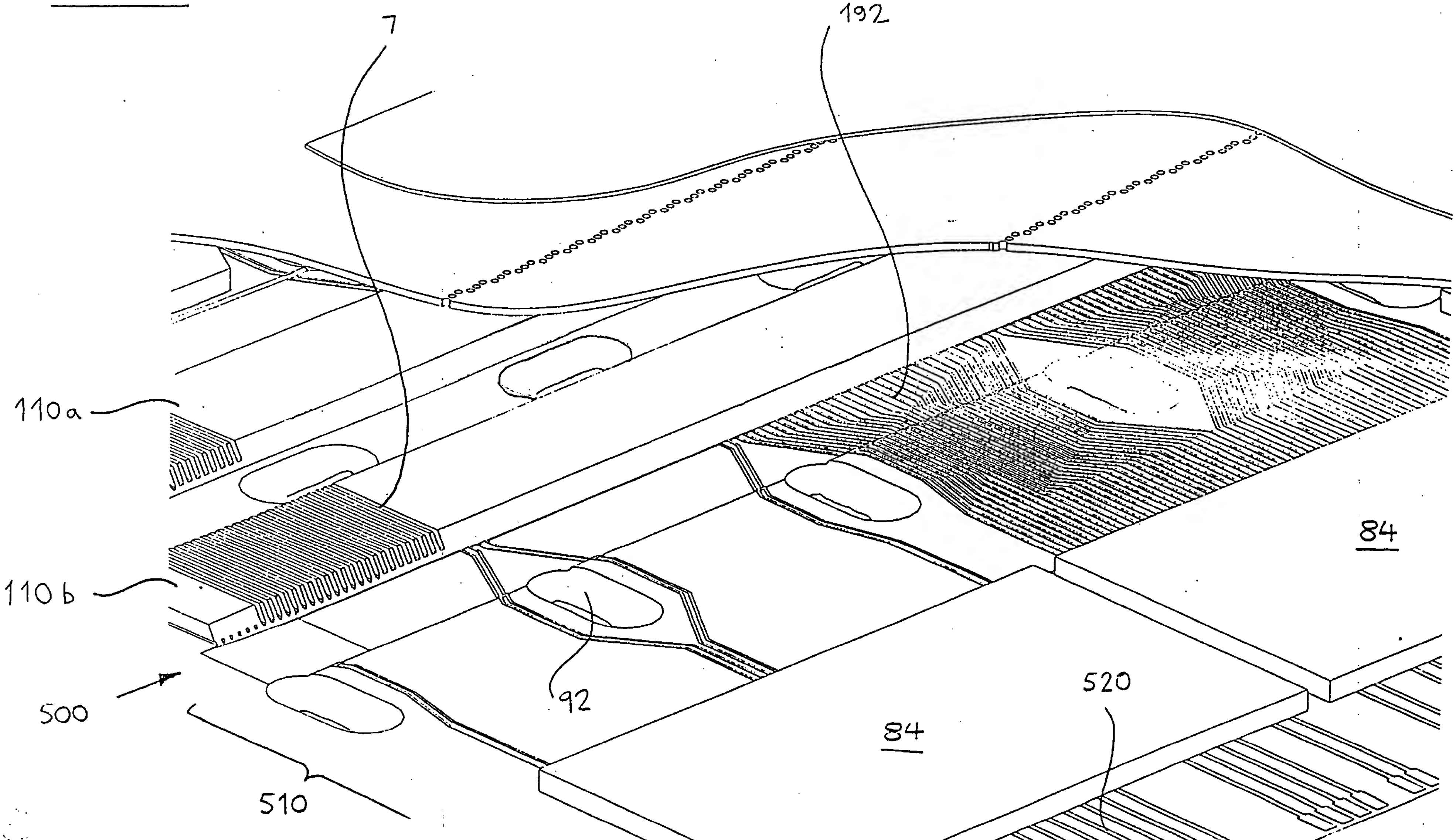


Fig. 14

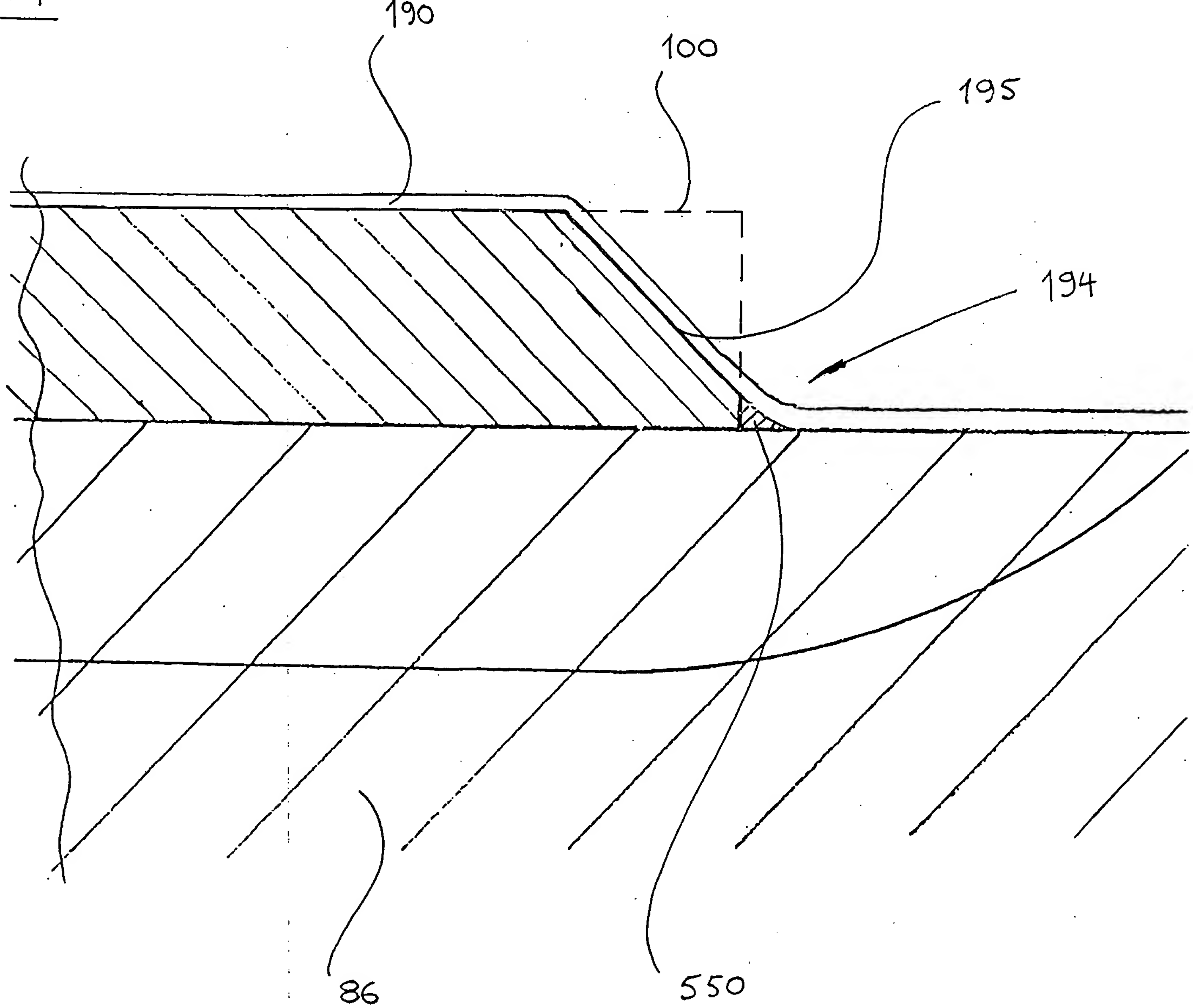


Fig. 15

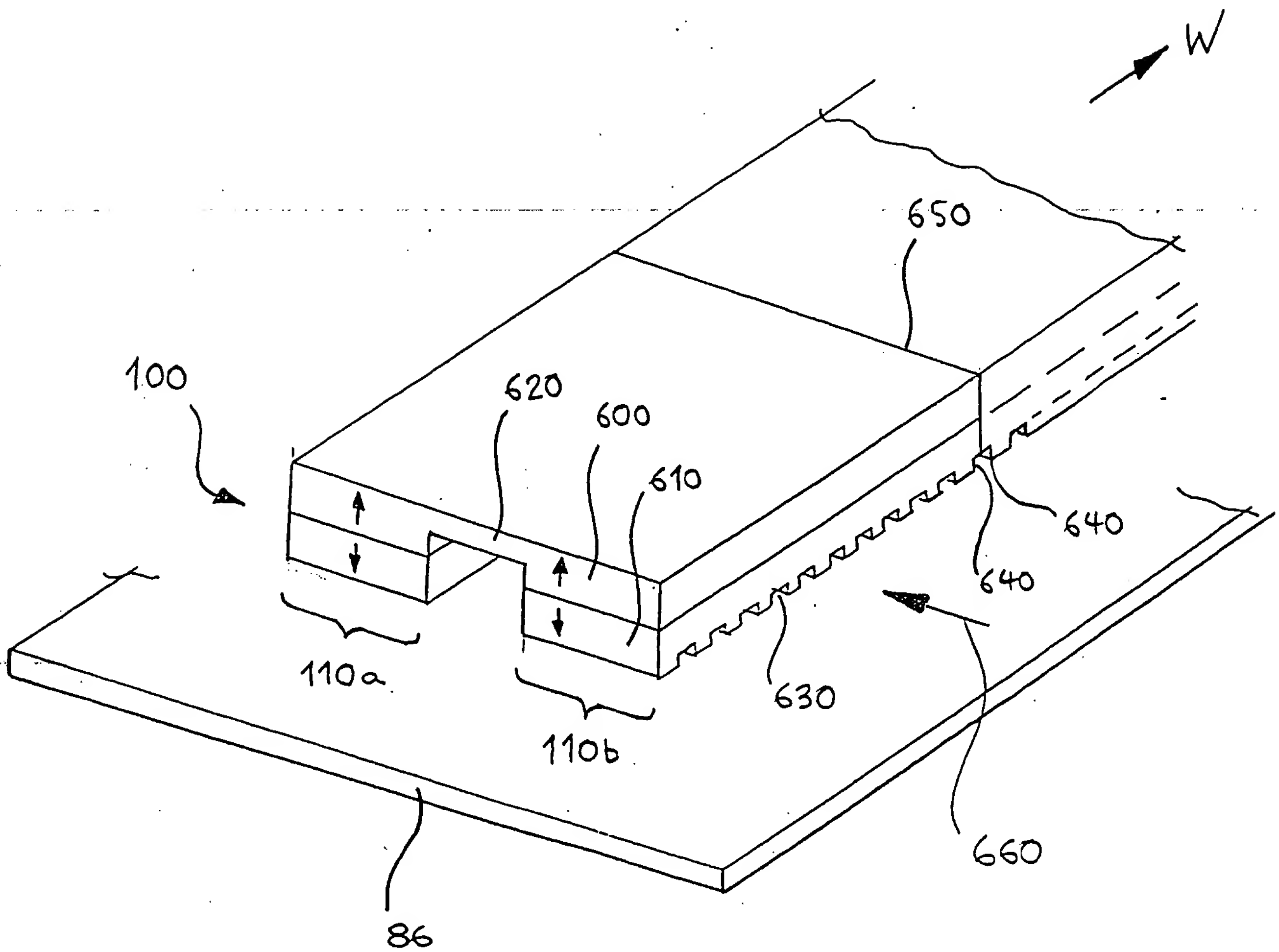


Fig. 16

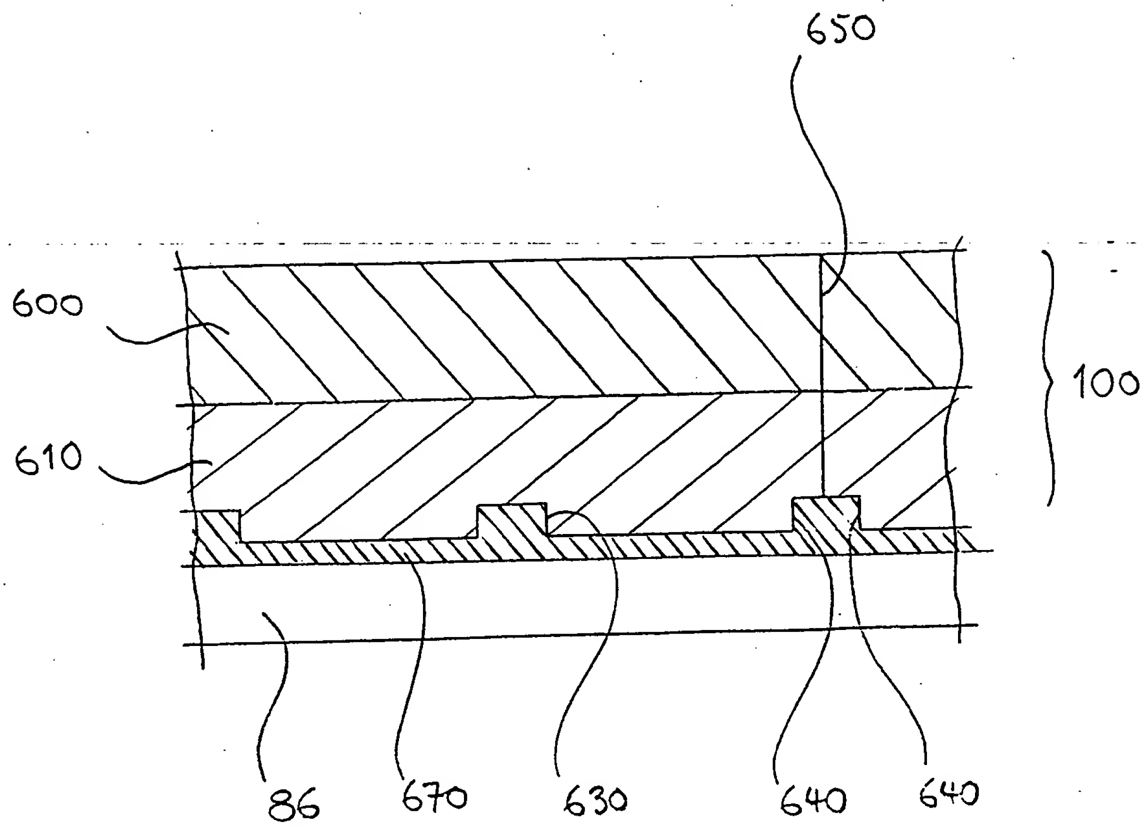


Fig. 17

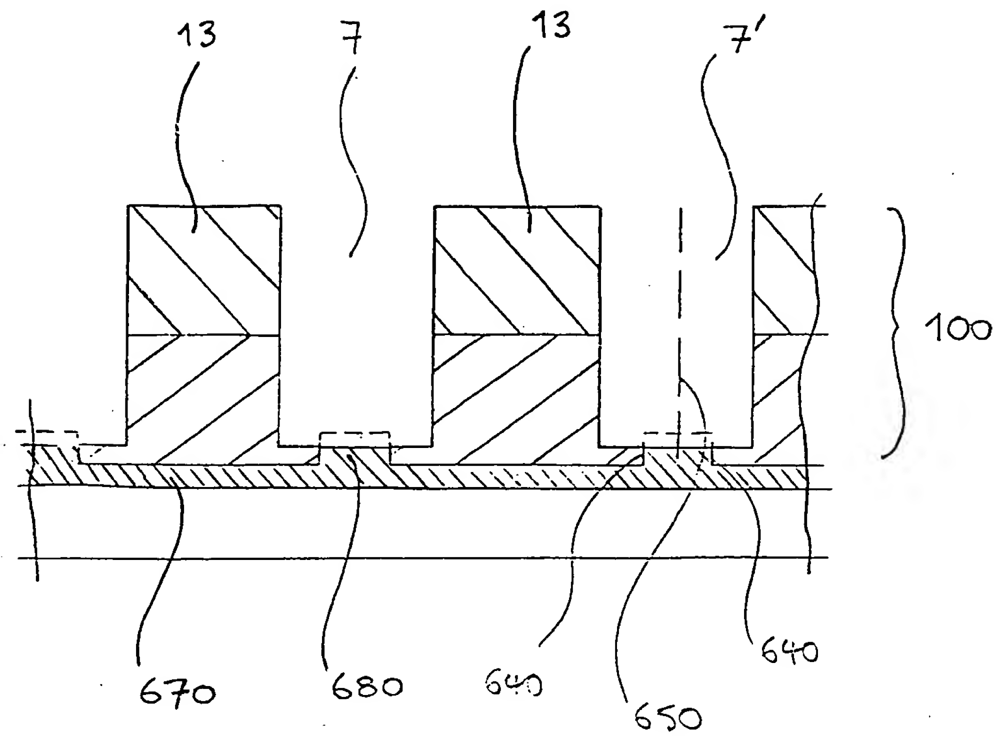
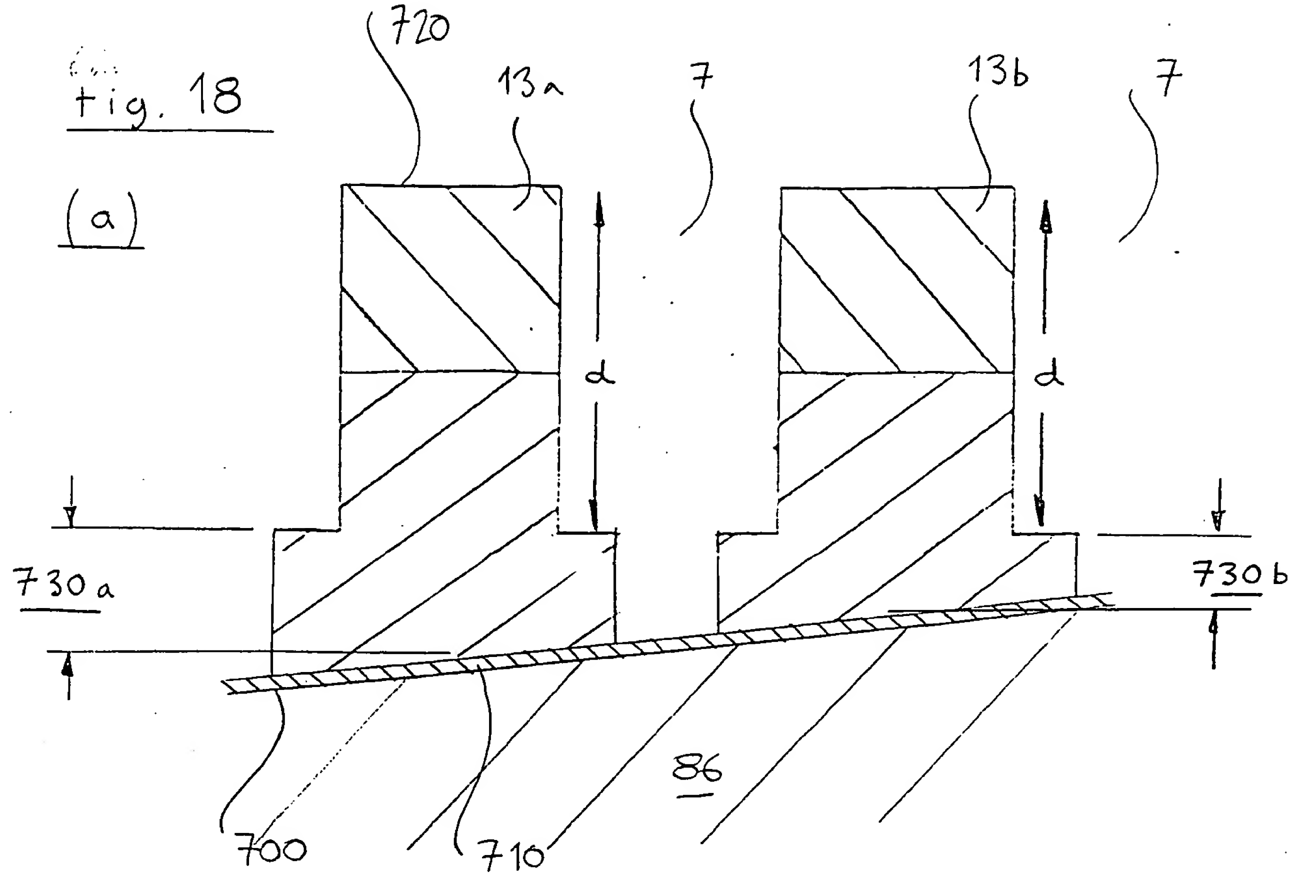


Fig. 18

(a)



(b)